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PNW-295 April 1977

DOUGLAS-FIR TUSSOCK MOTH EGG HATCH AND LARVAL DEVELOPMENT IN RELATION TO PHENOLOGY OF WHITE FIR IN SOUTHERN OREGON [1]

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Abstract

Bud burst, shoot elongation, egg hatch, and larval development were studied on two areas near Fort Klamath, Oregon. The study areas had low population levels of the Douglas-fir tussock moth. Bud burst was found to be closely related to accumulated degree-days, and peak egg hatch occurred after all buds had burst and shoots were 40 percent elongated. Larval development then closely followed shoot elongation. The findings are similar to those from earlier studies in California and northeastern Oregon.

KEYWORDS: Insect populations, larval growth, reproductive behavior (insect), bud burst, shoot growth, phenology, white fir, Douglas-fir tussock moth, Orgyia pseudotsugata, *Oregon (southern).*

INTRODUCTION

The phenology of Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), and its hosts has been studied and reported in California (Wickman 1976b) and northeastern Oregon (Wickman 1976a). In both studies the synchrony of insect and host phenology was noted, particularly egg hatch following bud burst. This synchrony between insect and host means that new foliage, which is obligatory food for early instar larvae, is available immediately after egg hatch.

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Studies of tussock moth population ecology in the Fort Klamath, Oregon, area in 1976 offered an opportunity to determine the phenology of insect and host in an additional area to see if the synchronous relationships were similar to those observed in previous studies. This area was particularly valuable since it is one of the few known white fir (*Abies concolor*) (Gordon and Glendenning) Lindley) stands in the West with a static low-level tussock moth population. Also, the stand is located approximately midway between the sites of earlier phenology studies in the Central Sierra Nevada of California and the Blue Mountains of northeast Oregon.

This study also provided phenology and degree-day information for concurrent population studies which facilitated sampling and scheduling of other research activities.

METHODS

The methods were similar to those used by Wickman (1976a) in the northeastern Oregon study.

LOCATIONS OF STUDY AREAS

In April 1976, two study sites were located in an area with a low-level tussock moth infestation near Mare's Egg Spring, (10 km) southwest of Fort Klamath, Oregon. Each site was also the location of a population study plot. Two elevations were sampled:

Population plot C--4,500-foot (1 350-m) elevation, eastern exposure, open-grown mixed white fir, ponderosa pine (*Pinus ponderosa* Laws.); second growth, thinned stand.

Population plot H--4,200-foot (1 250-m) elevation, eastern exposure, open-grown mixed white fir, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine; old-growth stand.

At each plot eight open-grown white fir trees, 8 to 15 feet (2.4-5 m) in height, were marked. There were some Douglas-fir on plot H, but small sample size trees were difficult to locate so only one Douglas-fir was tagged and measured.

TEMPERATURE RECORDS

Air temperature recording stations, consisting of 31-day recording hygrothermographs and a maximum-minimum thermometer in a standard weather shelter, were located on each plot.

A threshold temperature of 42 °F (7 °C) was used so that the study was comparable with previous tussock moth phenology studies (Wickman 1976a, 1976b). The sum of daily average temperatures above 42 °F was used for accumulated heat units. Accumulated degree-days for each plot were calculated from these heat units.

FOLIAGE SAMPLING

Each study tree had four tagged primary branches on the four cardinal sides of the midcrown. In April one terminal bud on each branch was marked measured, and examined and then remeasured at 3- to 6-day intervals from May 19 through the period of bud development, egg hatch, and dispersal of new larvae from the egg masses. Additional measurements were made at midseason (July 8) and after shoot growth ended (August 10 and September 8).

For this study, bud burst is defined as the time when individual needles first begin to protrude from the transparent sheath encasing

Errata

Research Note PNW-295

Douglas-fir Tussock Moth Egg Hatch and Larval Development in Relation to Phenology of White Fir in Southern Oregon

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Please insert the following revised fig. 3 and table 4.

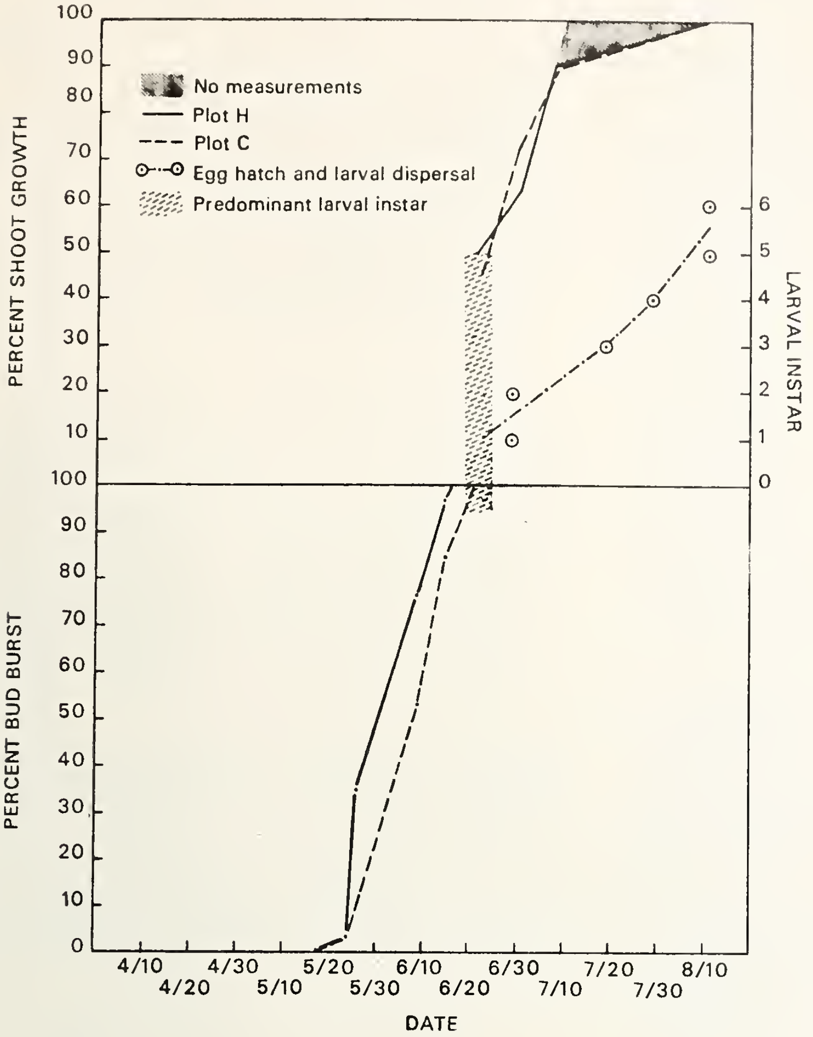

Figure 3.--Percent bud burst and shoot growth by date related to egg hatch, larval dispersal, and larval development for plots C and H, Mare's Egg Spring, Oregon, 1976.

Table 4--*Average shoot growth and degree days, Mare's Egg Spring, Oregon, plots C and H, 1976*

Date	Plot C			Plot H		
	Degree-days	Average shoot length	Accumulated growth	Degree days	Average shoot length	Accumulated growth
		Inches (cm)	Percent		Inches (cm)	Percent
6/22	584	0.97 (2.46)	47.1	674	1.36 (3.45)	50.7
6/29	714	1.51 (3.84)	73.3	811	1.72 (4.37)	64.2
7/8	871	1.83 (4.65)	88.8	983	2.39 (6.07)	89.2
8/10	1,579	2.06 (5.23)	100.0	1,712	2.68 (6.81)	100.0

expanding buds and are available to the young larvae for feeding.

EGG MASS EXAMINATIONS AND LARVAL SAMPLES

In late March, laboratory-reared egg masses were wired on four mid-crown branches on two sample trees per plot. By late April, 12 of the 16 egg masses had been partially or totally destroyed, probably by birds. The design was then changed to monitor field collected egg masses used for the population studies.

In mid-June, 10 egg masses were wired on 10 white fir branches on a population study plot at the same elevation (4,200-foot, 1 250-m) and 0.5 mile (0.8 km) south of plot H. These egg masses were examined once or twice a day through the period of egg hatch and dispersal. Peak hatch was defined as an egg mass almost completely covered by new larvae.

Using a standard sampling technique, Mason (1977) sampled feeding larvae from the lower crown foliage of 100 nearby trees on each plot every 3 weeks until pupation. The predominant larval instar at a given sample date was then compared with average shoot growth.

RESULTS AND DISCUSSION

Field measurements involved several steps which demonstrated a relationship between the phenology of the tussock moth and white fir, its principal host at Fort Klamath. Degree-days were accumulated by date and compared between the two plots to point out elevational differences; then degree-days were compared with bud burst at each site. Egg hatch was monitored and related to degree-days and bud burst; and, finally, shoot elongation was compared with egg hatch, larval dispersal, and larval development. The results for these comparisons follow.

DEGREE-DAYS AND BUD BURST

Degree-day accumulation was related to elevation with the lower plot (H) several days ahead of the higher plot (C) (fig. 1). Figure 2 shows bud burst by degree-days for white fir on each plot and reveals a fairly consistent pattern of development. Bud burst monitored on the single Douglas-fir at plot H is not graphed, but it consistently lagged several days behind bud burst of white fir on the plot. This was also true of other Douglas-fir observed in the area. In northeastern Oregon in 1973 Douglas-fir buds burst several days after grand fir at higher elevations also; but at low elevations (3,200 feet, 975 m) the reverse was true (Wickman 1976a).

The bud burst data in figure 3 indicate that the elevational differences of 300 feet (100 m) between plots was sufficient to reflect developmental delay of bud burst as proposed by Hopkin's Law (1918).

Bud burst often occurred first on open-grown trees, but as bud burst progressed there was no substantial difference by aspect in the crown. This agrees with findings in northeastern Oregon and California (Wickman 1976a, 1976b).

Bud burst as plotted in figure 2 started between 313 and 347 degree-days and proceeded rapidly until 90 percent of the bud burst had occurred between 500 and 510 degree-days. These values, shown in table 1, are higher than those found in northeastern Oregon but close to those found in California (Wickman 1976a, 1976b). The reasons for the differences in Oregon might be related to difference in spring weather between

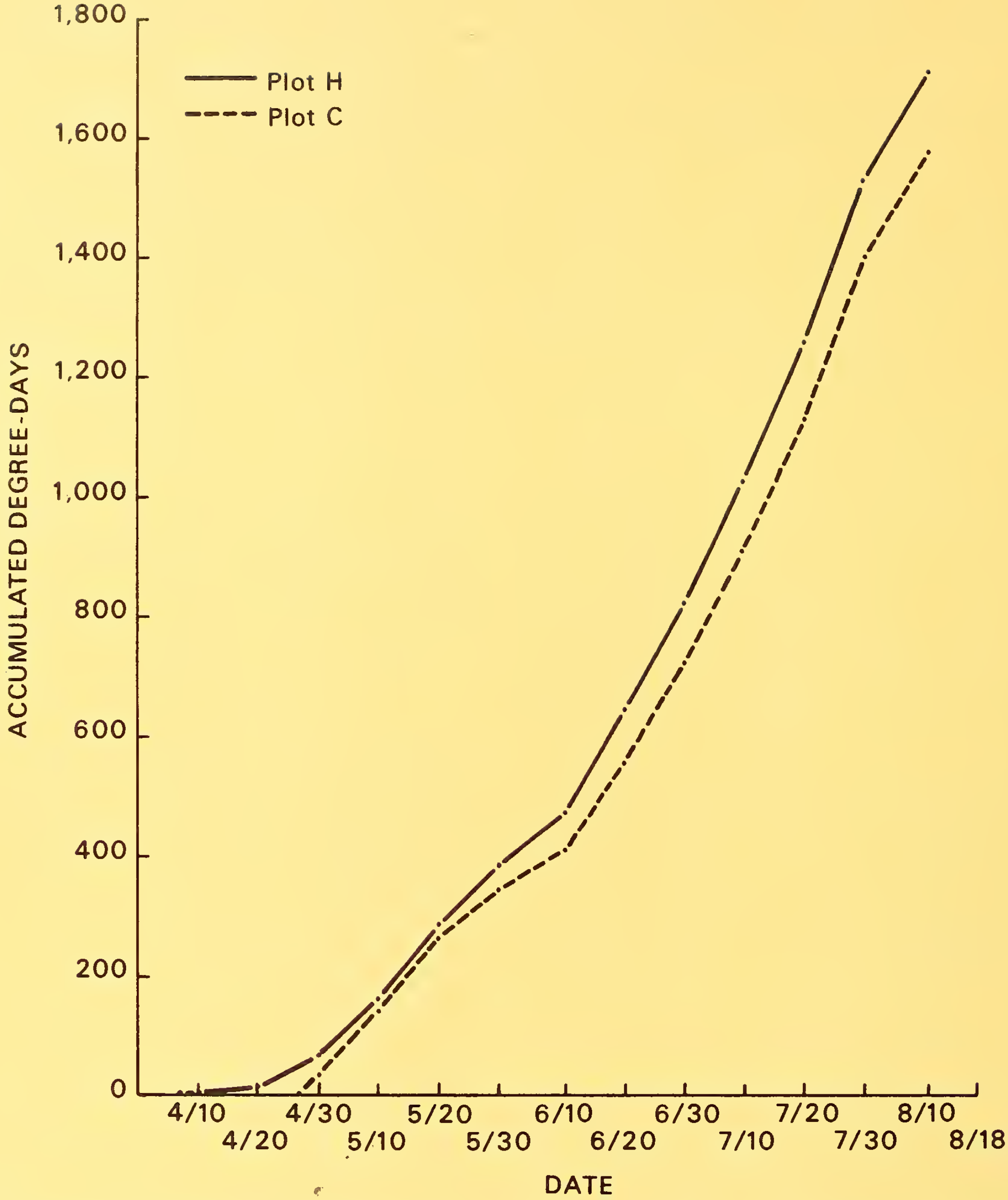

Figure 1.--Accumulated degree-days, April-August 1976, on phenology plots, Mare's Egg Spring, Oregon.

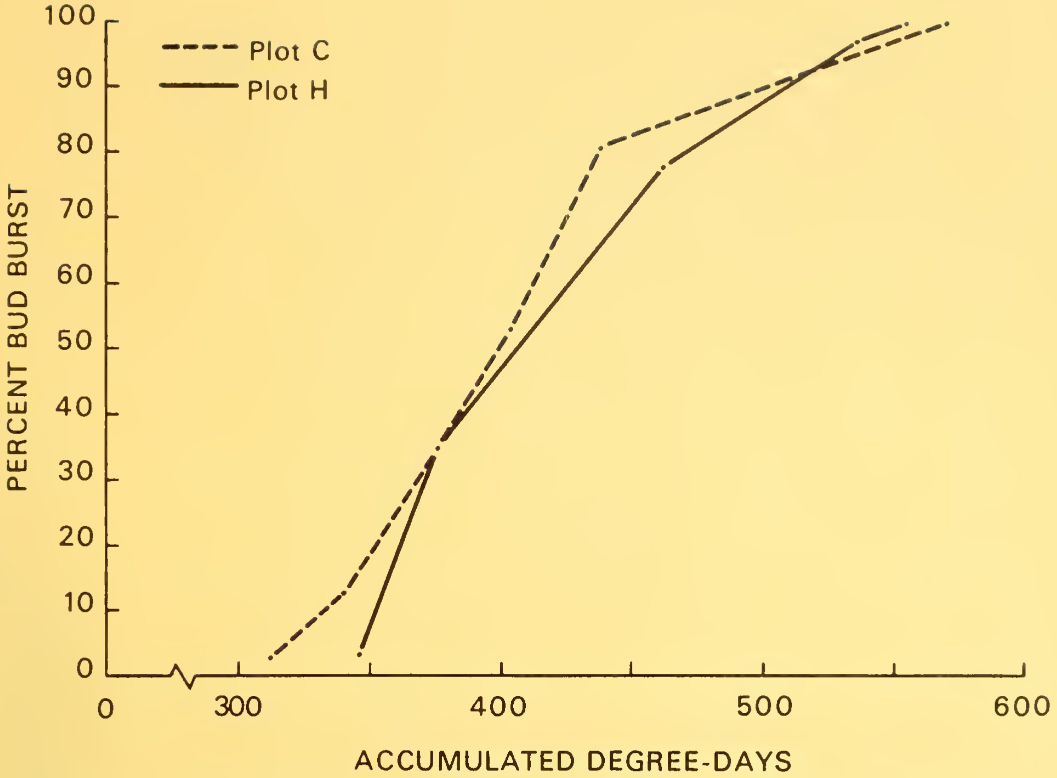

Figure 2.--Accumulated degree-days and percent bud burst, May-June 1976, on phenology plots, Mare's Egg Spring, Oregon.

localities and years. The same host is involved in both areas so, probably, southern Oregon phenological events are more similar to those in central California.

DEGREE-DAYS, BUD BURST, AND EGG HATCH

The relationship of egg hatch on the nearby population study plot to accumulated degree-days at plot H is shown in table 2. The sample is small (10 egg masses) because of scarcity of naturally deposited egg masses and their use for population studies. Also, the egg masses were monitored 0.5 mile (0.8 km) from plot H, but at the same elevation and in a similar stand. Egg hatch and dispersal from these 10 egg masses took place in 7 days with a degree-day accumulation of 625 at first hatch and 725.5 at peak hatch and dispersal. The data were not quantified the same way as for previous studies because of a shortage of egg masses, but, in this study, the time frame for egg hatch and dispersal is shorter than the 7-14 days in northeastern Oregon or the 13-17 days in California (Wickman 1976a, 1976b).

The egg hatch data are also suspect because egg masses were wired on exposed branches with a muslin drop cloth permanently fastened about 20 inches (50 cm) under each egg mass. This arrangement probably resulted in more

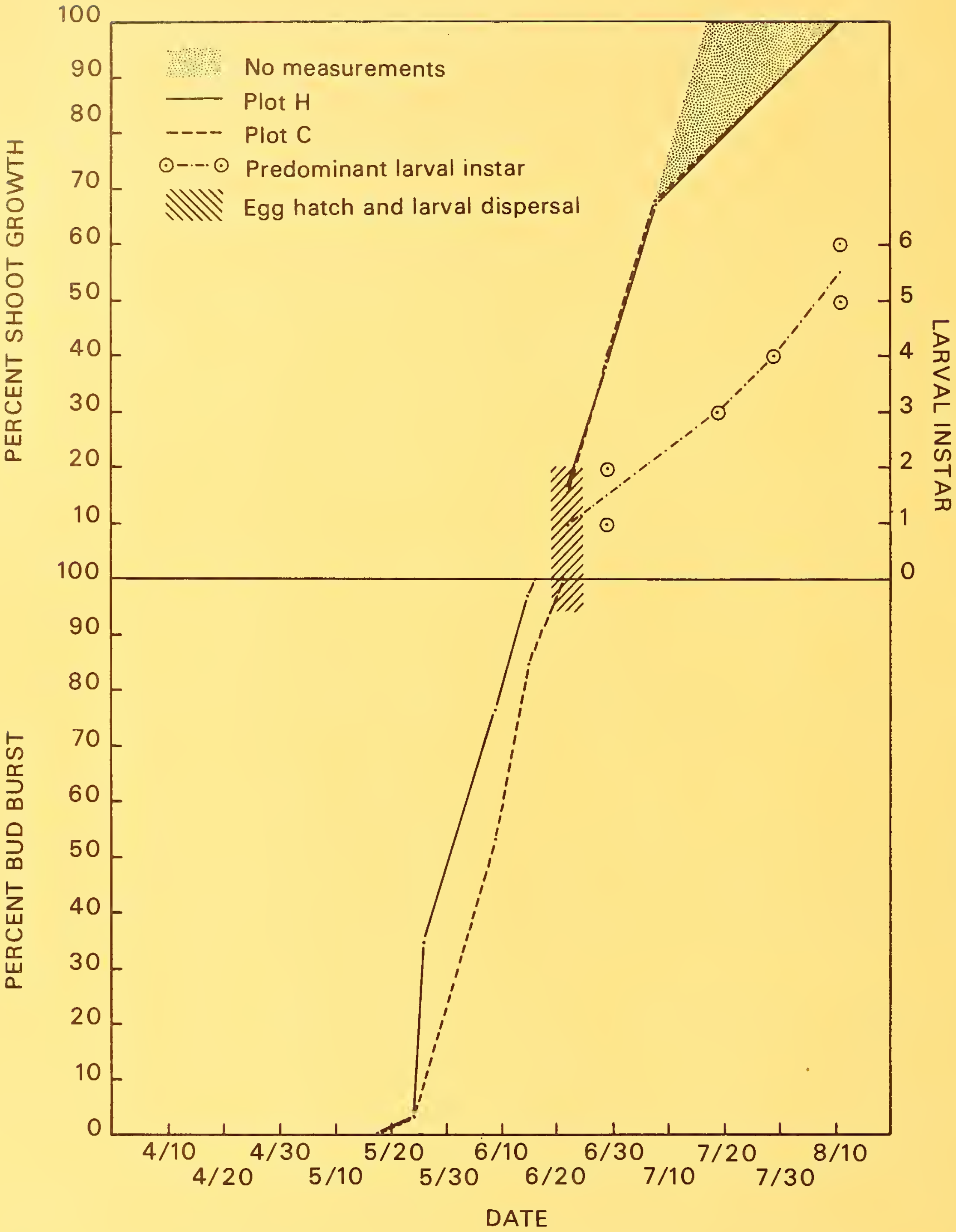

Figure 3.--Percent bud burst and shoot growth by date related to egg hatch, larval dispersal, and larval development for plots C and H, Mare's Egg Spring, Oregon, 1976.

Table 1--*Accumulated degree-days related to bud burst at 3 locations*

Location	First bud burst	90 percent bud burst
	Degree-days	
Central California	290-356	464-535
Southern Oregon (Fort Klamath)	313-347	500-512
Northeastern Oregon	244-268	340-386

Table 2--*Egg hatch and dispersal from 10 egg masses collected on the plot site and attached to branches for population studies, Fort Klamath, Oregon, 1976*

Date	Degree-days	Unhatched	Hatch underway	Peak hatch and dispersal
			Number	
6/19	625	9	1	0
6/22	674.5	2	3	5
6/23	692	2	--	8
6/24	711	0	2	8
6/25	725.5	0	0	10

exposure to solar radiation than that received by egg masses used in previous studies. The increased solar radiation may have resulted in a shorter period for egg hatch.

Calendar date plotted against percent bud burst and egg hatch is illustrated by figure 3. Figure 3 indicates that first egg hatch occurred after 100 percent bud burst on plot H. We had no equivalent measurements for plot C. Table 3 compares the two earlier studies (Wickman 1976a, 1976b) with this study. Because of the small egg sample in this study, comparisons of egg hatch with the other areas are tenuous, but other values are similar for the three areas which indicates synchrony of bud burst with egg hatch. Most important, by the time all larvae had dispersed from the egg masses to new foliage and were feeding, all buds had burst and shoots were over 40 percent elongated. This value is intermediate to shoot elongation in California (10-20 percent) at complete dispersal from egg masses and in northeastern Oregon (85-90 percent).

Table 3--*First egg hatch related to percent bud burst at 3 locations*

Location	Host	Percent bud burst (at first egg hatch)
Central California	White fir	63-86
Southern Oregon	White fir	100
Northeastern Oregon	Grand fir	86-100
Northeastern Oregon	Douglas-fir	70-97

SHOOT ELONGATION AND LARVAL DEVELOPMENT

Average shoot length and cumulative percent growth by date and degree-days are shown in table 4. The time that shoot growth was completed is not known because of a long period in late summer when no measurements were taken (shaded portion at top of fig. 3). The configuration of shoot growth curves in the northeastern Oregon and California studies (Wickman 1976a, 1976b) indicate that growth was completed sometime between July 15 and August 11, most likely the last week of July.

The trend is similar to the California and northeastern Oregon studies, with rapid shoot elongation accompanying larval development. By the third and fourth instars, between 80 and 90 percent of the shoot growth had taken place; this assured an adequate food supply for the rapidly growing larvae. Food supply was more than adequate for this particular population. But in northeastern Oregon in 1973 food supply was critical for the extremely large populations, and shoot growth was 90 percent complete by the second instar (Wickman 1976a). In California, where populations were sparse, 50 percent of the shoot growth had

Table 4--*Average shoot growth and degree days, Mare's Egg Spring, Oregon, plots C and H, 1976*

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		Inches (cm)	Percent		Inches (cm)	Percent
6/22	584	0.97 (2.46)	15.2	674	1.36 (3.45)	16.7
6/29	714	1.51 (3.84)	38.9	811	1.72 (4.37)	37.8
7/8	871	1.83 (4.65)	67.7	983	2.39 (6.07)	67.1
8/10	1,579	2.6 (6.52	100.0	1,712	2.68 (6.81)	100.0

taken place during the third and fourth larval instars (Wickman 1976b). Again, Fort Klamath was intermediate between California and northeastern Oregon.

As in the other studies, aspect caused no appreciable difference in shoot growth, either by development rate or total length.

CONCLUSIONS

This study indicated similar phenological relationships for tussock moth egg hatch and larval development on white fir in southern Oregon, white fir in central California, and grand fir and Douglas-fir in northeastern Oregon. The study area near Fort Klamath had almost the same relationship of degree-days and bud burst as the California study site and almost the same relationship of percent bud burst at egg hatch as the northeastern Oregon study site; it was intermediate between the California and northeastern Oregon areas for shoot elongation and larval development relationships. None of the differences seemed great, but limited sample sizes, and the artifact of each study carried out in a different year prevented tests for significance.

The important finding was that the relationships seem so consistent between areas and years. Some variation is bound to occur because of differences in tussock moth populations, host species, stands, physiography, and climatological seasons, but for the three studies the phenological synchrony between insect and host seems consistent.

This consistency also underscores the use of bud burst and shoot elongation as field predictors of egg hatch and larval dispersal rather than monitoring of individual egg masses.

ACKNOWLEDGMENTS

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